

Revelations: A Decidable Class of POMDPs with Omega-Regular Objectives

Marius Belly, Nathanaël Fijalkow, Hugo Gimbert,
Florian Horn, Guillermo A. Pérez, **Pierre Vandenhove**

IJCAI-ECAI 2026 — *Sister Conferences Best Papers Track*
Originally published at AAAI-25

LABORATOIRE
BORDELAIS
DE RECHERCHE
EN INFORMATIQUE

LaBRI

IIRF
INSTITUT
DE RECHERCHE
EN INFORMATIQUE
FONDAMENTALE



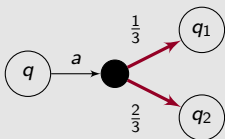
University
of Antwerp

UMONS
Université de Mons

POMDPs

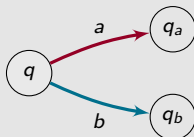
A **partially observable Markov decision process** is a finite graph that combines:

Stochasticity



Stochasticity determines the successor state.

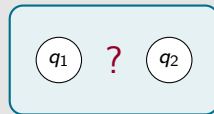
Decisions



The agent chooses actions.

Partial observations

same observation o



The observation may not identify the state.

To make it interesting, we still need an **objective** for the agent.

Objectives and verification

Long-run objectives

Parity objectives are a canonical representation of ω -**regular objectives**:
reachability, safety, infinitely many visits. . .

Undecidability for general POMDPs

Quantitative

Reach a target state with probability $\geq t$,
for $t \in (0, 1)$?

Undecidable.

Qualitative

Satisfy a general parity objective
almost surely (with probability 1)?

Undecidable.

Which restrictions yield **qualitative** decidability?

A verification viewpoint

The same model supports **complementary questions**.

Optimization / learning

Which policy performs well?



Expected performance.

Formal verification

Does there exist a strategy that satisfies the objective?



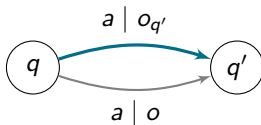
Offline, exact mathematical guarantee.

Here: what is **decidable**, and at what **complexity**?

One class we introduced

Strong revelations

For every possible transition $q \xrightarrow{a} q'$,
there is a **positive probability** of receiving an observation that **uniquely identifies** q' .



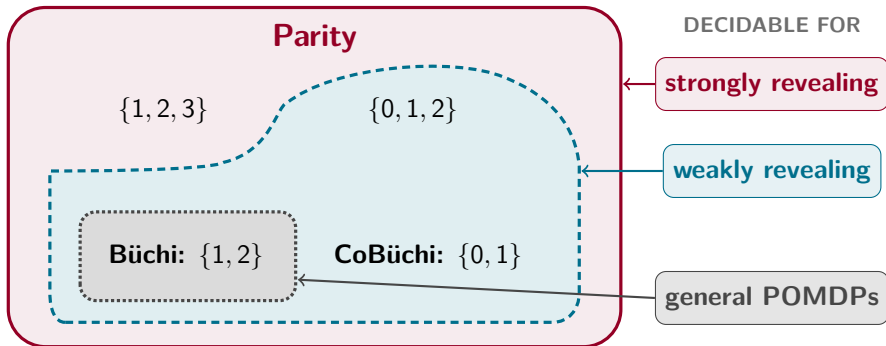
Main result

For **strongly revealing** POMDPs,
the existence of an almost-sure strategy for parity objectives is **decidable**.

Algorithm idea: track only the **set of states that remain possible** (the **belief support**)
 $\implies$ solve a finite abstraction.

Decidability hierarchy

The paper also introduces **weak revelations** — not covered in this talk.



All decidable cases shown are EXPTIME-complete.

Conclusion

TAKE-HOME MESSAGE

While verification is undecidable for general POMDPs, there is hope: there are **natural and expressive decidable subclasses**.

[Code and experiments on GitHub](#)

Paper



arXiv:2412.12063

Thanks!